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John F. Kennedy Space Center, Florida

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Expendable Launch Vehicles Program

PROGRAM/PROJECT MANAGEMENT INSTRUCTION

**RESPONSIBLE OFFICE: ELV LAUNCH SERVICES DIRECTORATE, VEHICLE
ENGINEERING DIVISION**

SUBJECT: ENGINEERING REVIEW PROCESS (ERP)

EXECUTIVE SUMMARY:

This Program/Project Management Instruction defines and directs the function, review, and disposition of technical issues of the Vehicle Engineering Division, as well as Engineering Review Board (ERB) criteria and membership.

APPROVAL

//Original Signed by// Date: 12-01-2000
Darren M. Bedell
Chief, Vehicle Engineering Division

Avoid Verbal Orders

DATE: 1 December, 2000

ORG: VB-A

TO: Michael J. Benik, VB

SUBJECT: Engineering Review Process Initial Release

The attached document is the first release of the Engineering Review Process (ERP) that documents the most significant function, review and disposition of technical issues, of the Vehicle Engineering Division. The ERP documents how we have been doing business. However, since there has been no structured way to approach the documentation and resolution of engineering issues, an Engineering Review Sheet (ERS) will be incorporated. The ERS will be used to document, communicate, and close engineering issues for NASA's ELV fleets. This will provide visibility to "significant" items that do not result in an Engineering Review Board (ERB).

As a subset of the ERP, the ERB criteria and membership has also been documented. The ERB is essentially unchanged from the current process. One additional set of criteria has been established that now requires Mission Unique technical requirements to go to the ERB. The ERB will provide recommendations for the use of Ishikawa Fishbone analysis and/or Technical Design Reviews, and technical viability of the requirement. The purpose of the new criteria is to allow structured judgment in the use of the ELV risk analysis tool of choice.

The process has been briefed to the Division, is effective as of December 4, 2000, and is now under configuration control. My intent is to keep the current process, as enhanced by this document, as efficient as possible. Therefore, there may be a number of changes, mostly for clarification and efficiency, as the implementation gets started. With the proximity to the holidays, I do not expect the use of ERS's, or the first ERB for an Interface Control Document initial release until January 2001.

FROM: //Original Signed by//
Darren M. Bedell
Chief, Vehicle Engineering Division

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VB-A, all NASA and Boeing support

Engineering Review Process

CHARTER

The engineering review process provides documented technical recommendations, with supporting rationale, from the Engineering Division to the ELV Project. The engineering review process is a review of technical adequacy, with no regard given to cost or schedule impacts associated with those recommendations. A rationale supporting a technical recommendation will not consider cost or schedule influences. However, it is acceptable to consider and provide recommendations addressing multiple courses of action (each with a distinct cost or schedule impact) associated with an engineering review item. A course of action may be proposed out of cost or schedule considerations, and the engineering review process will consider that course of action based solely on technical adequacy.

SCOPE

The scope of the engineering review process includes all technical recommendations made by the Engineering Division to the ELV Project. This includes, but is not limited to flight readiness determinations, design review recommendations (mission-specific and core vehicle), and evaluations of manufacturing, integration, and test adequacy¹.

OVERVIEW

The Engineering Review Process has three phases: Initiation, Resolution, and Disposition. This process defines the responsibility and authority, criteria, and implementation for each phase.

INITIATION

This phase opens the engineering review process by acknowledging and documenting that an issue or concern exists that requires engineering review.

Responsibility/Authority

Any engineer within the Engineering Division initiates the engineering review process. Subsystem cognizant engineers, analysts, Project Engineers and Vehicle Systems Leads normally initiate engineering review for core vehicle issues. For mission-specific and spacecraft interface issues, the Integration Engineer, analysts and subsystem cognizant engineers normally initiate engineering review.

Anyone outside the Engineering Division may initiate the engineering review process by bringing the technical issue to the attention of the Vehicle Systems Lead, Project Engineer, or assigned Integration Engineer. The Vehicle Systems Lead or Integration Engineer then becomes responsible for initiating the engineering review process.

Criteria

The engineering review process is initiated for every item² that satisfies one or more of the following criteria:

1. A flight observation or anomaly occurring on any mission flown on any ELV configuration used for NASA launches services.
2. A change in qualification status for any component on any ELV configuration used for NASA launch services. This includes, but is not limited to: a change in predicted flight environments impacting qualification margins; planned component requalification; or a discovery through audit or other review creating concern over qualification status.
3. Expected use on a NASA mission of a new or upgraded component within the first six (6) flights.

¹ Examples include: Atlas Tiger Teams, pedigree reviews (all vehicles), field processing test data reviews, and vehicle walkdowns.

² The term "engineering review item" or simply "item" will be used generically to identify a change, technical issue, requirement, or other technical concern under review.

Engineering Review Process

4. Every Class I change, identified thru the ELV Insight and Approval Process, to any component on an ELV configuration since the last NASA use of that configuration. Note that related Class I changes may be grouped and evaluated and documented as a single item.
5. Every mission-specific technical requirement for each NASA mission.
6. Any Class I change, deviation, or waiver to a mission-specific requirement for any NASA mission.
7. Significant non-conformances, test anomalies, or process deviations that a NASA engineer decides warrant additional investigation beyond that obtained during normal launch service provider engineering or product reviews.

Implementation

The Initiating Engineer:

- Verifies that the item is not already encompassed by an existing review as documented in an Engineering Review Summary (ERS).
- Documents the item on an Engineering Review Summary (ERS). The initiating engineer records a description of the review item, the applicability (fleet(s) or mission(s)), and preliminary recommendations for action, if any.
- Provides the ERS to the Vehicle Systems Lead (VSL) and, if a mission-specific change or issue is involved, the applicable Integration Engineer for the next affected NASA mission. If the item under review affects a component for which a Project Engineer (PE) has been designated, then the initiating engineer will provide the ERS to the PE, as well.
- Consults with the Vehicle Systems Lead, and, if applicable, the Integration Engineer or the Project Engineer on the ERS wording and recommended grouping of multiple Class I changes in a single ERS.
- Signs the ERS as the initiating engineer.
- Provides the “initiated ERS”, with signatures from the initiating engineer, Vehicle Systems Lead, and the Integration Engineer (if applicable), to the Engineering Review Coordinator (ERC).
- Provides electronic copy of the initiated ERS to the Engineering Review Coordinator (ERC).
- **Mission Specific Requirements:** The Integration Engineer (IE) is the initiating engineer for review of all mission specific technical requirements. Engineering review of every mission-specific requirement will be initiated by the IE and documented on an ERS. The intent is for the IE to initiate the first engineering review of the known mission-specific technical requirements prior to mission turn-on (at both LSTO initiation and just prior to ATP). Engineering review of mission-specific technical requirements prior to turn-on will be documented on a single ERS. The IE will subsequently initiate engineering review of the mission-specific technical requirements as documented prior to the first release of the mission ICD (or equivalent). The engineering review will occur within the typical contract timeline allowed for government approval of CDRLs (30 days). The ERS should not duplicate the Interface Control Document (ICD) (or equivalent document), but rather, use the ICD as a referenceable appendix to the ERS. Subsequent to the first release of the ICD (or equivalent), new mission-specific technical requirements, or Class I changes to mission-specific technical requirements, will be reviewed and documented as discrete items.

The Vehicle Systems Lead

- Resolves any disputes regarding problem statement or applicability between the initiating engineer, Vehicle Systems Lead, Project Engineer, or Integration Engineer.

The Vehicle Systems Lead, Integration Engineer, or Project Engineer (i.e. the assigned Systems Engineer)

- Consults with the initiating engineer and, if applicable, the Vehicle Systems Lead, on the wording of the draft ERS.
- Signs concurrence with the ERS initiation.

The ER Coordinator

- Assigns an ERS tracking number
- Places the original initiated ERS on file

Engineering Review Process

- Places a read-only electronic copy of the ERS on an ELV Project server
- Notifies the initiating engineer, Chief Engineer, Vehicle Systems Lead, Safety and Flight Assurance Office Chief, and Integration Engineer or Project Engineer (as applicable) that the ERS has been logged into the Engineering Division Engineering Review Database.

RESOLUTION

This phase includes all activities required to gather data and develop a recommendation and rationale to support disposition.

Responsibility / Authority

The Vehicle Systems Lead is responsible for the overall resolution of core vehicle items. In those cases where an item satisfies initiation criteria for both core vehicle and mission-specific review items, then the Vehicle Systems Lead remains responsible for the resolution of that item. The Vehicle Systems Lead is also responsible for periodically providing status on the resolution of core vehicle and combined items under review to the Chief Engineer and the ELV Project. If an ERB is required, then the Vehicle Systems Lead is responsible for ensuring that the ERB presentation is adequate to support board review and disposition.

The Integration Engineer is responsible for the resolution of mission-specific items. The Integration Engineer is responsible for periodically providing status on the resolution of mission specific items under review to the Chief Engineer and the ELV Project. If an ERB is required, then the Integration Engineer is responsible for ensuring that the ERB presentation is adequate to support board review and disposition.

The Mission Analysis, Vehicle Engineering, Integration Engineering, and Field Office Branch Chiefs are responsible for providing engineering support to resolve engineering review items. Specifically, this requires the assignment of a cognizant engineer for each review item. The Engineering Division Branch Chiefs assign additional engineers as required to support resolution of engineering review items.

The cognizant engineer is responsible for gathering data and developing recommendations and rationale to support resolution of an assigned item.

Criteria

An engineering review item is resolved when:

- Adequate data has been gathered to support recommendations and rationale for disposition
- The cognizant engineer has proposed disposition recommendations and rationale.
- The Vehicle Systems Lead, Project Engineer, or the Integration Engineer has concurred with the cognizant engineer's disposition recommendations and rationale.

If an ERB is determined to be required for dispositioning an item, then that item is considered resolved when the following additional criteria are satisfied:

- An ERB has been requested, and assigned a tracking number
- The ERB presentation package has been completed and provided to the ERB Coordinator

Implementation

The Cognizant Engineer

- Gathers data from supporting engineers, other NASA sources, and the LSP engineers. The cognizant engineer will maintain this data in a separate file (electronic or other) for each item under review.
- Develops and proposes disposition rationale to the Vehicle Systems Lead, Project Engineer, or Integration Engineer
- Develops the ERB presentation, if an ERB is required.
- Provides regular, informal, resolution status updates to the Vehicle Systems Lead, Project Engineer or Integration Engineer

Engineering Review Process

- Reviews item resolution status and supporting data for satisfaction of criteria requiring disposition by ERB.
- Notifies the Vehicle Systems Lead, Project Engineer, or Integration Engineer if, at any time, the item resolution status and supporting data satisfy the criteria requiring disposition by ERB.

The Vehicle Systems Lead, Project Engineer, or Integration Engineer (Systems Engineer)

- Reviews and concurs with disposition recommendations and rationale proposed by the cognizant engineer
- Reviews and concurs with the ERB presentation, if an ERB is required
- Reviews resolution status updates provided by the cognizant engineer
- Provides informal resolution status updates to the Chief Engineer and Integration Engineer (if applicable)
- Provides resolution status updates to the ELV Project per the requirements of the project status meetings (e.g. monthly review) and as specifically requested
- Reviews item resolution status and supporting data, along with the cognizant engineer, for satisfaction of criteria requiring disposition by ERB.
- Notifies the Chief Engineer if, at any time, the item resolution status and supporting data satisfy the criteria requiring disposition by ERB.

The Integration Engineer (if applicable)

- Provides informal resolution status updates to the Mission Integration Team

The Chief Engineer

- Reviews resolution status updates
- Reviews item resolution status and supporting data, along with the cognizant engineer and Vehicle Systems Lead, Project Engineer, or Integration Engineer, for satisfaction of criteria requiring disposition by ERB.

DISPOSITION

Responsibility / Authority

The Chief Engineer is responsible for ensuring that all engineering review items are dispositioned in accordance with this process, regardless of whether or not an ERB is required for disposition. The Chief Engineer is the ERB Chairman. The Chief Engineer is authorized to resolve all disputes associated with the disposition of an engineering review item. The Chief Engineer is responsible for briefing the Engineering Division Chief and Branch Chiefs on the resolution of all disputes associated with disposition of an engineering review item. The Chief Engineer is authorized to designate engineers to act in the place of an ERB member, in the absence of a prior designation by that member or other extenuating circumstances. The Chief Engineer and the Engineering Division Chief are authorized to designate an acting ERB chairman.

The Engineering Division Chief and Branch Chiefs are responsible for providing all necessary engineering support required to disposition an engineering review item in a timely manner. The Engineering Division Chief and Branch Chiefs are responsible for serving as members of the ERB, and are authorized to designate engineers to act in their places, as required. The Vehicle Engineering Division Branch Chiefs are responsible for ensuring that the engineers presenting to an ERB understand the presentation requirements. The Engineering Division Chief, Chief Engineer and Branch Chiefs may, upon review of a dispositioned ERS, require that the item be dispositioned by ERB.

The Engineering Division Chief and Chief Engineer are authorized to jointly determine that disposition actions recommended by an ERB have been satisfied, without reconvening the ERB.

The Vehicle Systems Lead, Project Engineer or Integration Engineer is responsible for concurring with the disposition recommendations and rationale proposed by the cognizant engineer. The cognizant engineer is responsible for briefing the disposition recommendations and rationale to the Chief Engineer or ERB. The Vehicle Systems Lead, Project Engineer, or Integration Engineer is authorized to assign the cognizant

Engineering Review Process

engineer or other supporting engineers to brief the Chief Engineer or ERB, where such an assignment will improve the quality of the technical discussion and lead to a more effective disposition. However, the overall responsibility for ensuring that the disposition recommendation and rationale are briefed to the Chief Engineer or ERB rests with the Vehicle Systems Lead, Project Engineer, or Integration Engineer.

The cognizant engineer and supporting engineers are responsible for supporting the disposition of an engineering review item. This responsibility may include briefing the Chief Engineer or Engineering Review Board.

In those cases where an engineer disputes the disposition recommendations and rationale presented to the Chief Engineer or ERB, then that engineer is responsible for immediately identifying that dispute to the Chief Engineer.

Criteria

An engineering review item is dispositioned when:

- The Chief Engineer, Cognizant Engineer, and Vehicle Systems Lead, Project Engineer or Integration Engineer have determined that the item does not require ERB disposition
- The Chief Engineer, Cognizant Engineer, and Vehicle Systems Lead, Project Engineer or Integration Engineer has concurred with the disposition recommendations and rationale.

OR

- The ERB has been convened
- The ERB has provided recommendations and rationale
- The ERB or Chief Engineer and Engineering Division Chief concurs that all actions required for disposition have been satisfied.

Implementation

The Cognizant Engineer

- Documents disposition recommendations and rationale on the ERS
- Presents disposition recommendations and rationale to the Chief Engineer
- Supports presentation of disposition recommendations and rationale to the Chief Engineer by providing detailed review item background or additional supporting rationale.
- Supports Chief Engineer review by satisfying actions and requests for additional information assigned by the Chief Engineer
- Signs concurrence with disposition recommendations and rationale documented on ERS.

Or (When ERB disposition is required)

- Presents disposition recommendations and rationale to the ERB
- Supports presentation of disposition recommendations and rationale to the ERB by providing detailed review item background or additional supporting rationale.
- Supports ERB review by satisfying actions and requests for additional information assigned by the ERB Chairman.
- Revises ERS disposition to reference ERB number (it is not necessary to repeat the ERB recommendations and rationale on the ERS).

The Vehicle Systems Lead, Project Engineer, or Integration Engineer

- Ensures that disposition recommendations and rationale are documented and presented to the Chief Engineer
- Supports Chief Engineer review by satisfying actions and requests for additional information assigned by the Chief Engineer
- Signs concurrence with disposition recommendations and rationale documented on ERS.

Engineering Review Process

- When the IE dispositions Class I changes to mission specific technical requirements, then the IE notifies the Chief Engineer that the change has been dispositioned and provides the recommendations to the MIM/MIT.

Or (When ERB disposition is required)

- Ensures that disposition recommendations and rationale are documented on an ERS (see above).
- Signs concurrence with disposition recommendations and rationale documented on ERS.
- Supports cognizant engineer presentation of recommendations and rationale to the ERB.

The Integration Engineer (when mission specific items are dispositioned by ERB)

- Provides ERB recommendations to the MIM and MIT.

The Chief Engineer

- Reviews disposition recommendations and rationale
- Assigns additional actions required to complete disposition or support rationale
- Signs concurrence with disposition recommendations and rationale documented on ERS (except for Class I changes to mission specific technical requirements)

Or (When ERB disposition is required)

- Convenes and chairs the ERB or designates an ERB chairman

The Chief Engineer or Vehicle Engineering Division Chief

- Briefs ERB recommendations and rationale to the Project Decision Meeting, as appropriate.

The ERB Chairman (When ERB disposition is required)

- Conducts the ERB
- Ensures that a minimum of three board members (including the chairman) are present prior to convening an ERB
- Assigns additional actions required to complete disposition or support rationale
- Documents Board recommendations and rationale on an ERB Recommendations and Rationale form
- Determines, in consultation with the other ERB members, whether or not the situation warrants a flight constraint to be imposed or lifted for NASA missions
- Explicitly documents the existence, extent, and recommended measures associated with any flight constraint on the ERB Recommendations and Rationale form

And (When ERB is chaired by other than the Chief Engineer)

- Briefs Board recommendations and rationale to the Chief Engineer

Engineering Review Process

Engineering Review Board “Trigger Criteria”

An ERB is required to disposition an engineering review item that satisfies one or more of the following criteria:

1. **Flight Anomaly**: A flight data anomaly occurring on any mission flown on any ELV configuration used to provide launch services to NASA. A flight observation does not require disposition by an ERB.
2. **Qualification Status Change**: A change in qualification status for any component on any ELV configuration used for NASA launch services. This includes, but is not limited to: a change in predicted flight environments impacting qualification margins; planned component requalification; or a discovery through audit or other review creating concern over qualification status.

Note that these criteria for qualification status changes raises questions with respect to Class I changes. For the particular subset of concerns over qualification status due to known component Class I changes, no ERB is required when the VSL and ELV cognizant engineers determine that the as-changed component remains qualified based on similarity to the original qualification baseline. If disagreement exists over the nature of qualification status concerns in this respect, then the Chief Engineer or Vehicle Engineering Division Chief shall resolve those disagreements.

3. **First Flight Item**: Expected use on a NASA mission of a new or upgraded component within the first six (6) flights.
4. **Major Non-conformance**: Expected use on a NASA mission of a component that fails to conform to the applicable specification to a degree that may threaten mission success.
5. **Mission Specific Technical Requirements**: An ERB is required to convene and provide recommendations to the Integration Engineer for requiring Ishikawa-style fishbone analysis and formal design reviews (e.g. PDR, CDR, DCR) for implementation of mission specific technical requirements. The ERB will also provide recommendations to the IE regarding the technical viability of the mission specific requirement. All known mission-specific technical requirements will be presented to an ERB at each of the following milestones:
 - a) Prior to launch service task order (LSTO) or request for proposal (RFP) release (if applicable)
 - b) Prior to the ELV Project Decision Meeting (PDM) that recommends mission authorization to proceed (ATP)
 - c) Prior to first release of the mission interface control document (ICD), or equivalent.
6. **Major Design Reviews for NASA-Funded Vehicle Upgrades and Mission Specific Requirements**: Every PDR, CDR, and DCR will have an associated NASA ERB that runs concurrent with the LSP design review forum. At least one permanent board member will be required to participate as the ERB Chairman. The IE (or a substitute designated by the Integration Engineering Branch Chief) for the affected mission becomes a required board member in this case. The PE (or a substitute designated by the Vehicle Engineering Branch Chief), if applicable, is also a required board member in this case.

It is recognized that this ERB may also operate concurrently with the review activities of other design review team members (e.g. S&FA, MIT, Hanger AE) representing the ELV Project. The other members of the project team, and their responsibilities, are described in the appropriate project process.

Engineering Review Process

Definitions

Definitions

Flight observation: An event occurring during vehicle flight that is unusual or unexpected.

The ER process will be initiated for all flight observations, with the observation documented on an ERS. Once the investigation is complete, the results of the investigation will be documented in the Resolution section of the ERS. Note that an observation is not considered a launch constraint.

An ELV Project Vehicle Systems Lead (VSL) makes the determination that a flight event is an "observation". This determination is made in consultation with cognizant ELV Project engineers and appropriate LSP systems engineers. The VSL notifies the ELV Project Chief Engineer of all flight observations.

Flight anomaly: A flight observation where concerns exist regarding the success of future missions.

An ELV Project ERB must disposition a flight anomaly. An anomaly is a launch constraint until dispositioned otherwise by an ELV Project ERB.

The determination whether a flight event is a flight observation or flight anomaly is made by the ELV Chief Engineer, in consultation with the appropriate ELV Project VSL and Launch Service Provider (LSP) Chief Engineer. Note that the LSP Chief Engineer normally makes this determination for the launch service provider, and the ELV Project VSL and Chief Engineer may or may not concur with the LSP Chief Engineer's determination. In practice, however, the ELV Project VSL and Chief Engineer rarely dispute the LSP Chief Engineer's determination of observation versus anomaly.

First Flight Item: First use of a Class I change that:

- a) alters vehicle performance; or
- b) alters interface requirements between core vehicle subsystems; or
- c) alters component vendors, even if no interface requirements are affected; or
- d) alters component qualification status; or
- e) results from a significant vendor process change during component manufacture

Class I engineering change: This definition is tailored from MIL-STD-973B, section 5.4.2.2.1. An engineering change shall be classified as Class I by the ELV Project Vehicle Engineering Division in accordance with this definition. Classification disagreements shall be referred to the ELV Chief Engineer for final decision. An engineering change to a component, interface, or to any combination or discrete portion thereof, shall be determined to be Class I by examining the factors below to determine if they would be impacted as a result of implementing the change. The change shall be considered Class I if:

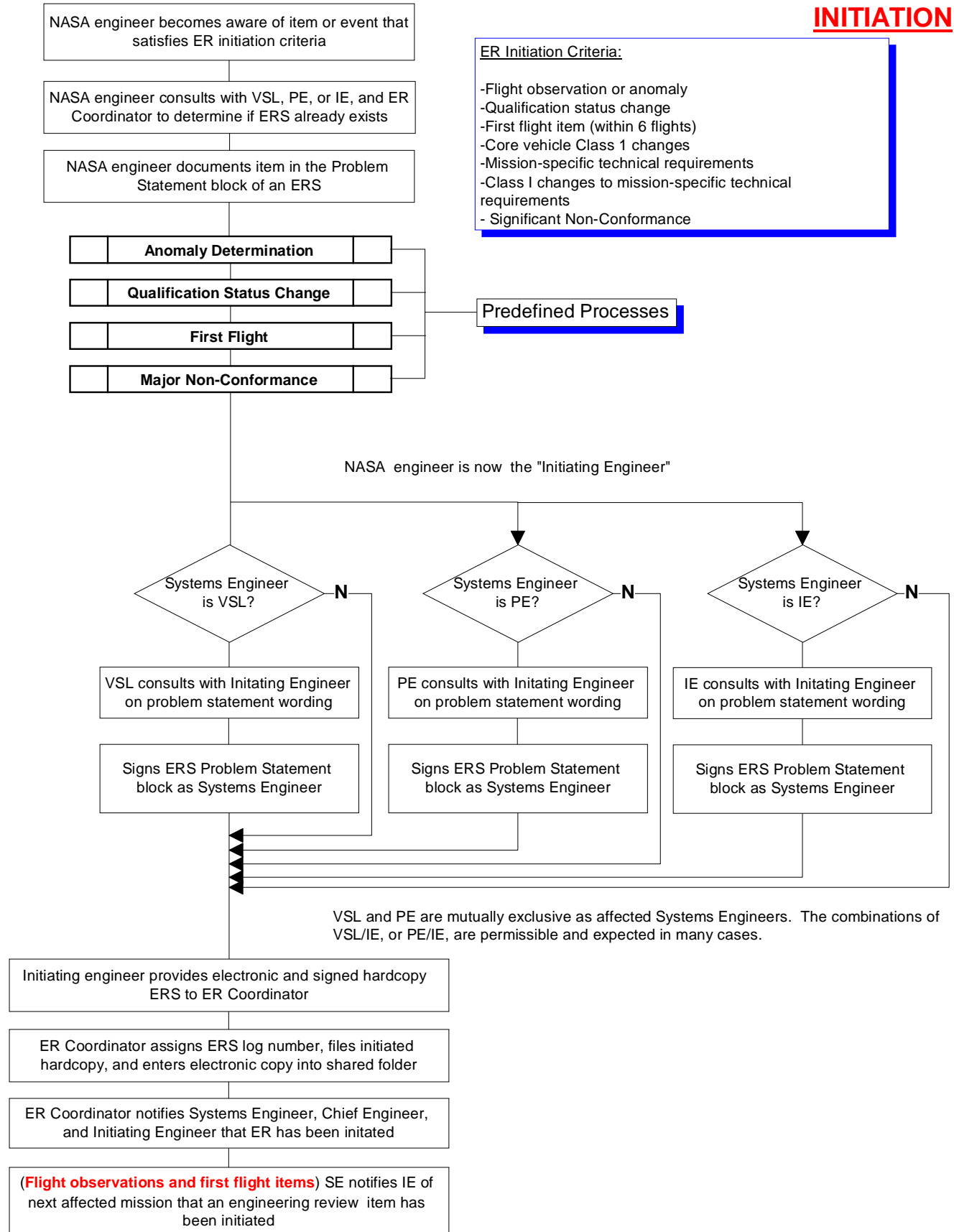
- a. The component or interface specification, once established, is affected to the extent that any of the following requirements would be outside the specified limits or specified tolerances:
 - (1) Performance
 - (2) Weight, balance, moment of inertia
 - (3) Interface characteristics
 - (4) Electromagnetic characteristics
 - (5) Other technical requirements in the specification
- b. The change has the potential to impact:
 - (1) Component or system reliability
 - (2) Safety

Engineering Review Process

- (3) Compatibility or interoperability with other components GSE, launch control systems, or flight software
- (4) Configuration to the extent that retrofit action is required.
- (5) System or component operating limits.
- (6) Component or part sources.

Engineering Review Process

INITIATION

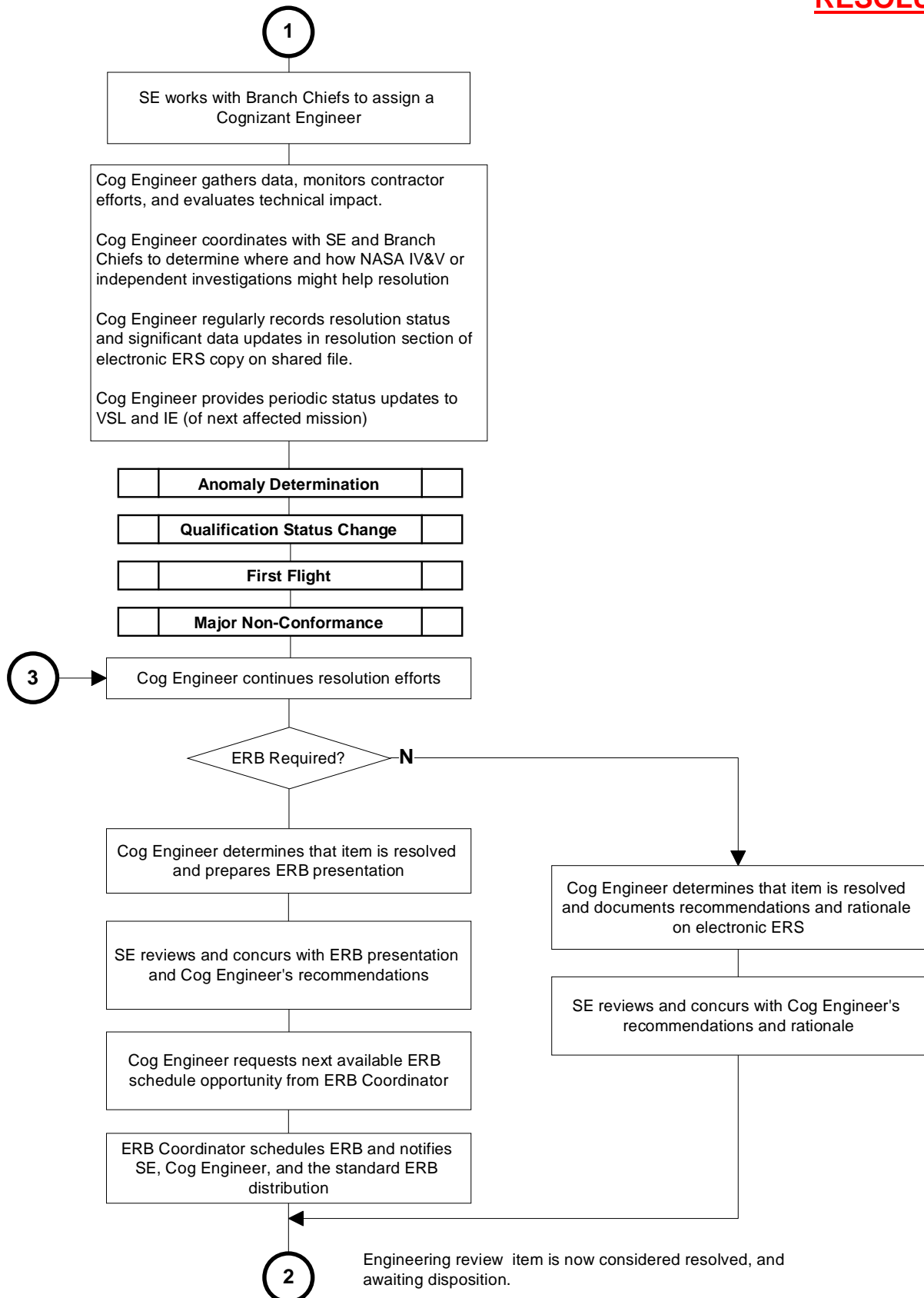


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Engineering review has now been initiated for this item. The ERS will be tracked and recorded as a Vehicle Engineering Division record of engineering review.

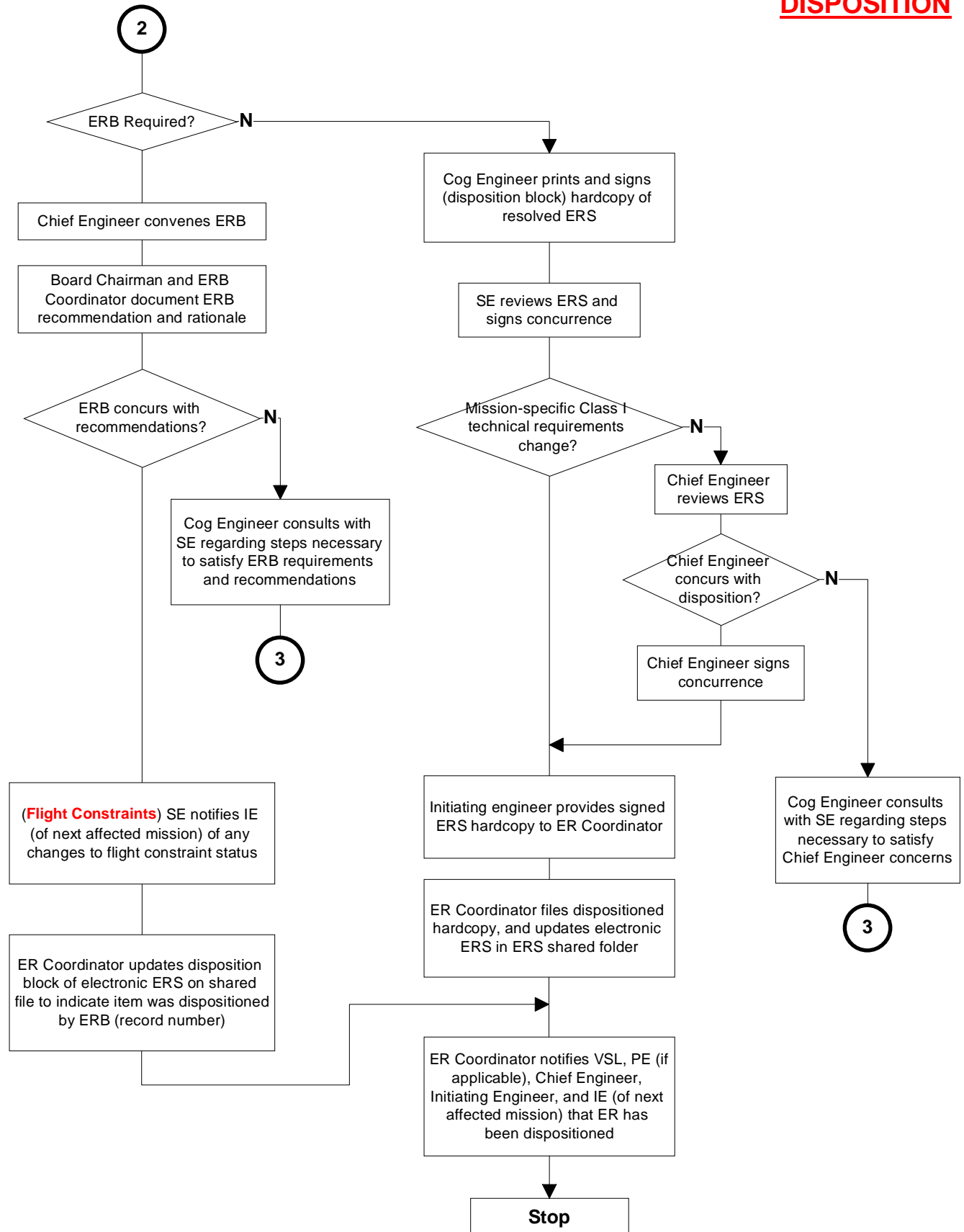
Engineering Review Process

RESOLUTION



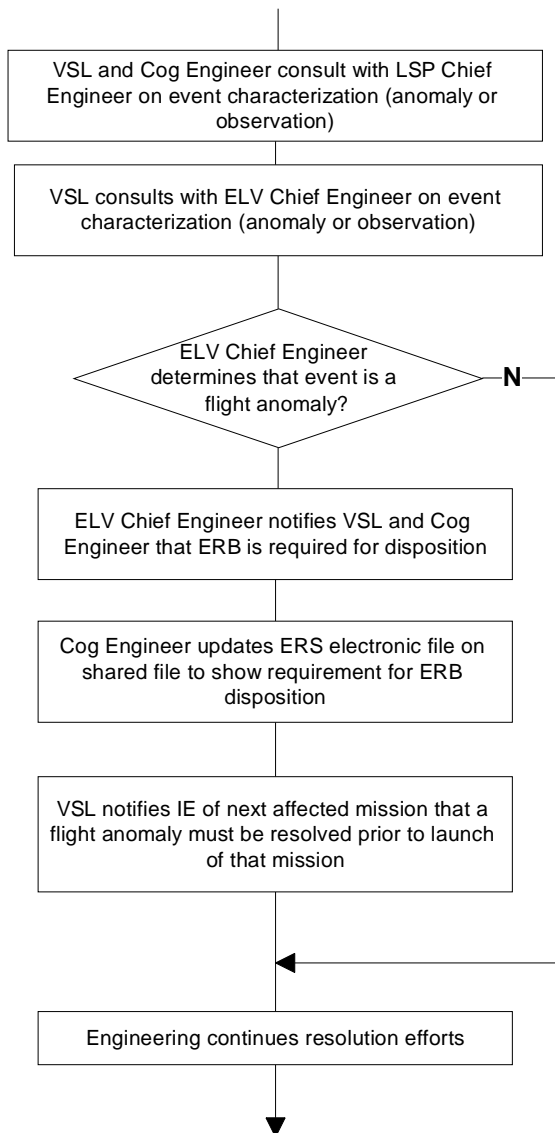
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DISPOSITION



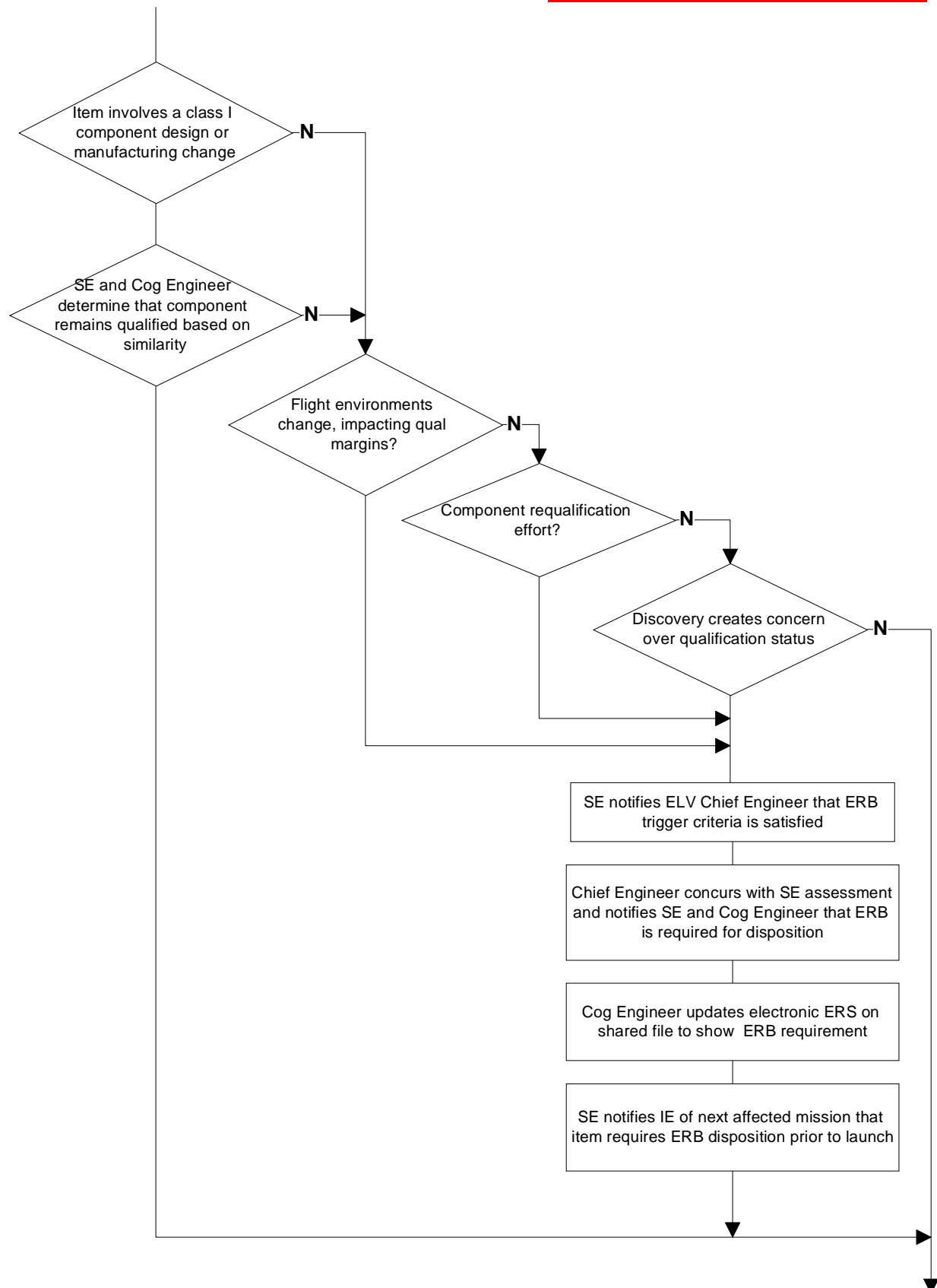
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ANOMALY DETERMINATION



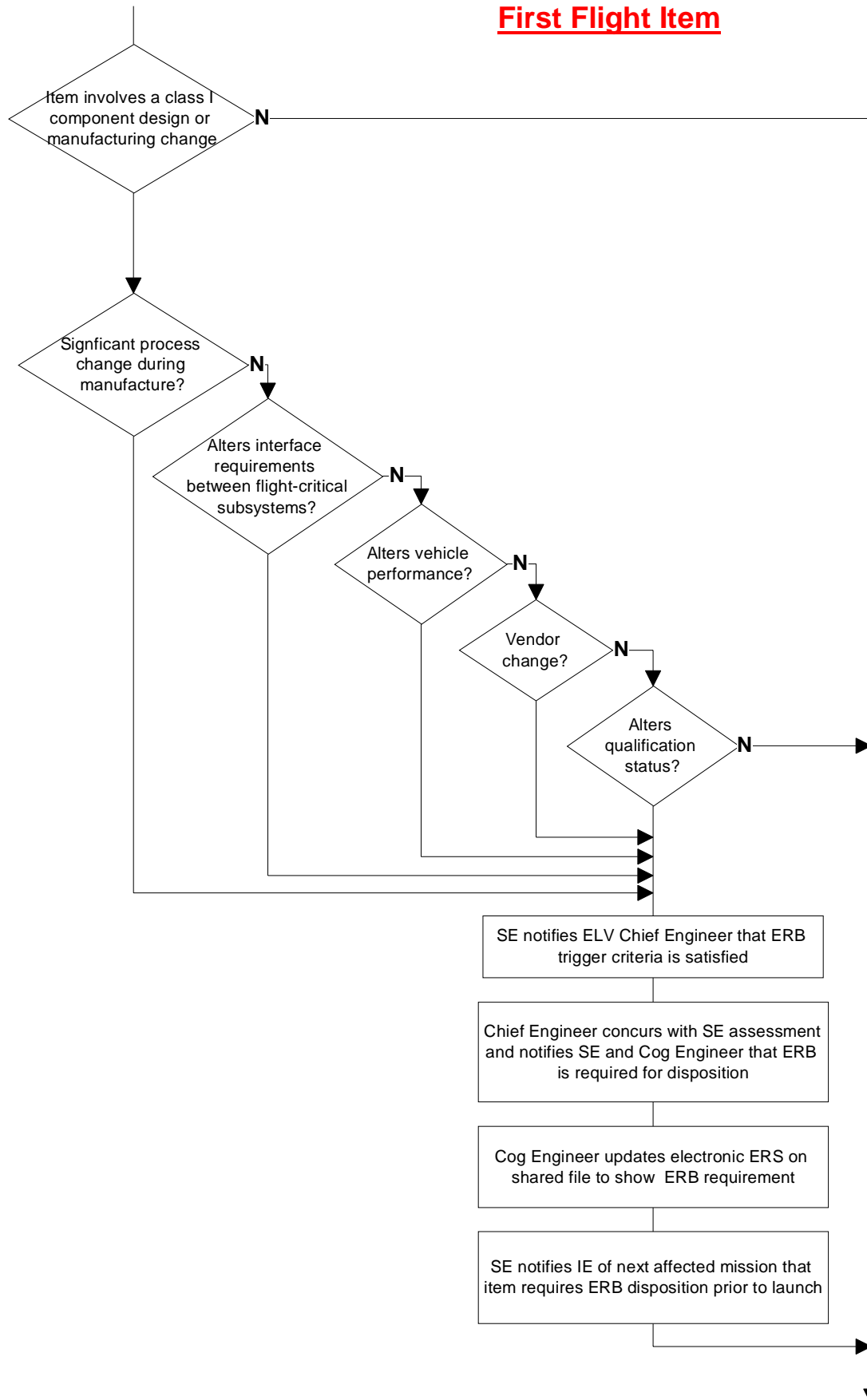
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Qualification Status Change



Engineering Review Process

First Flight Item



Engineering Review Process

Major Non-Conformance

